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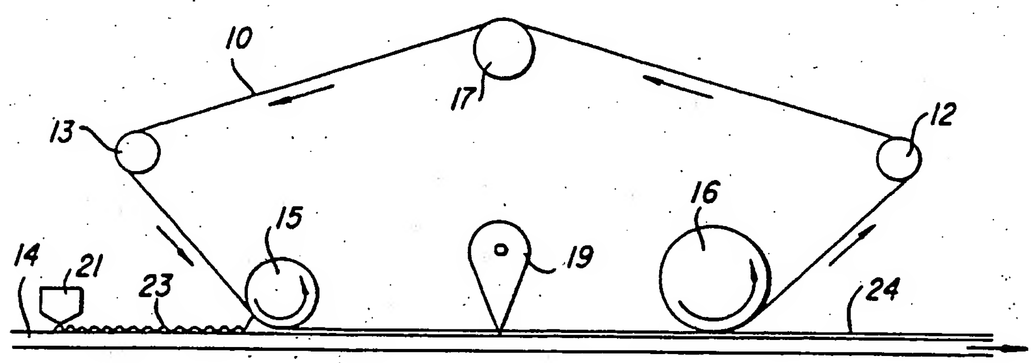

(57) Abstract

A laminar impressor for coating flat substrates, such as thermoplastic sheets and films, with radiation-curable coating compositions. The laminar flexible impressor comprises a non-adhering impressor belt (10) which is impressed onto the uncured coating on the surface of the flat substrate (14). The coating is cured by irradiation while the impressor belt (10) is still in contact with the coating. The impressor belt is removed from the cured coating (24), leaving a firmly adhered coating into which the surface texture of the laminar belt (10) has been faithfully transferred.

* See back of page.

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A LAMINAR IMPRESSOR FOR COATING FLAT SUBSTRATES

Background of the Invention

This invention relates to an apparatus and method for laminating flat substrates. More particularly, the invention relates to an apparatus and method for applying laminar radiation-cured polymeric coatings to thermoplastic sheet and film.

Thermoplastic substrates, such as polycarbonate sheet and film, often are coated with polymeric coatings. These coatings have various protective and decorative purposes, such as imparting abrasion and chemical resistance, removing or masking surface imperfections, and providing a specialty surface. Such specialty surfaces range from glossy, smooth surfaces to matte or textured surfaces. Heretofore, if a textured surface coating were desired, it usually would be formed by impressing and thermoforming the cured surfaces with a heated roller or calendar. This procedure can only be used with coated surfaces which have at least some thermoplastic character. Many of the so-called "hardcoats," used to protect thermoplastics against abrasions, are highly cross-linked thermoset resins. Attempts to texture the surfaces of these coatings by thermoforming often results in rupture or separation of the coating, as it does not have adequate elongation characteristics.

Embossing the coated surfaces prior to curing has also been proposed. The radiation-curable acrylic coatings are typically viscous liquids prior to curing,

therefore, it is difficult to maintain the dimensional stability of the coating when the surface texture is formed prior to curing.

A need exists for an efficient procedure for applying surface-textured, hard, abrasion and chemical resistant coatings to thermoplastic sheets and film.

Summary of the Invention

In accordance with the present invention, a laminar impressor for the application of radiation-curable coatings to flat substrates comprises:

an impressor belt of non-adhering, flexible film; said belt having a surface texture which is the mirror image of desired surface texture on the flat substrate being coated;

means for conveying the flat substrate in a linear direction in the plane of its surface being coated;

a rotatable, cylindrical nip roll in closely spaced proximity to the moving surface of the flat substrate, the axis of rotation of the nip roll being substantially parallel to the surface of the flat substrate and substantially perpendicular to the direction of movement of the flat substrate, and the linear speed of the surface of the nip roll being substantially the same as the speed of movement of the flat substrate;

means for feeding the impressor belt between the nip roll and the surface of the flat substrate and biasing the impressor belt against the nip roll, such that it remains in contact with the nip roll and is closely spaced from the surface of the flat substrate; the feeding of said impressor belt being in the direction

of and at substantially the same speed as the speed of movement of the flat substrate;

means for applying a controlled amount of a radiation-curable polymeric coating composition to the surface of the flat substrate or the surface of the impressor belt upstream from the nip roll, such that, downstream of the nip roll, the coating composition is sandwiched between the surface of the flat substrate and the impressor belt;

means for directing radiation to the radiation-curable polymeric coating composition downstream from the nip roll, thereby substantially curing the coating composition to a solid state while the impressor belt is still in contact with the coating composition; and thereafter

removing the impressor belt, leaving the radiation-cured coating firmly adhered to the flat substrate and leaving an impression of the surface of the impressor belt on the surface of the radiation-cured coating.

The laminar impressor of this invention permits the application of a very uniform thickness of a surface coating to a flat substrate, such as a thermoplastic sheet or film. The apparatus is useful for accurately and efficiently forming a wide variety of surface textures to the coatings. The apparatus is particularly suited to large scale automated coating operations.

Brief Description of the Drawings

Figure 1 is a schematic diagram of a laminar impressor according to the present invention, which employs an endless impressor belt.

Figure 2 is a schematic diagram of a laminar impressor according to the present invention, wherein the

impressor belt is stripped from the coating for reuse or discard.

Figure 3 is a schematic diagram of a laminar impressor according to the present invention, wherein the impressor belt is left on the cured coating as a masking film, for subsequent removal by the user.

Detailed Description of the Invention

The laminar impressor of this invention employs a non-adhering impressor belt for impressing a desired surface texture into an uncured coating. The coating is radiation-cured while the impressor belt is still in contact with the coating, thereby insuring that the surface texture of the belt is faithfully transferred to the coating.

The impressor belt may be fabricated from a wide variety of materials. The belt is non-adhering, which, as used herein, means that the impressor belt can be stripped from the cured coating without removing the coating from the coated substrate. The impressor belt is constructed from a material which can be formed with the desired surface texture, and has sufficient surface resiliency that the texture will be transferred to the uncured coating composition.

In general, polymeric films, such as polyester and polyolefin films, have been found to be well-suited for the construction of impressor belts. These films can be embossed with a wide variety of surface textures, using a heated metal roller. Polyester and polyolefin films having leather and fabric textures, matte surfaces, smooth glossy surfaces, and many others are presently available commercially. Non-polymeric materials, such as thin-gauge metal, can also be used. As used herein, the term "texture" incudes surfaces ranging from glossy to

highly formed. By employing a surface treatment or a release coating, materials that might otherwise adhere to the cured coating may be used.

As will be discussed below, in a preferred embodiment, the coating is cured by irradiating it through the impressor belt. Therefore, the impressor belt preferably is transparent to the radiation used for curing the coating. Such coatings are typically cured with ultraviolet ("UV") light or electron beam ("EB") radiation. Polyester and polyolefin films are highly transparent to ultraviolet radiation, which is another reason for preferring these materials for the construction of the impressor belts. A wide range of materials can be used with EB radiation, since the degree of transparency to EB is related only to the mass of the material.

The compositions used for coating the substrates may be any of the well-known, radiation-curable polymeric coatings. Such coatings usually are based on acrylic resin systems, although other polymer systems are also used. One example of such a coating composition is described by James E. Moore, et al. in U.S. patent 4,107,391.

The coating advantageously has a viscosity in the uncured state such that it readily flows into the cavities and depressions of the impressor belt. The viscosity is preferably great enough to support the impressor belt and prevent flow-out of the coating composition prior to cure.

Virtually any flat substrate can be coated using the laminar impressor of this invention. Such substrates include thermoplastic substrates, metallic sheets, plywood, particle board, and certain fabrics, to name but a few. Preferred substrates include thermoplastic sheets

and films. Decorative and protective coatings for these materials greatly increase the scope of their application. Particularly preferred substrates are polycarbonate sheets and films.

The laminar impressor of this invention may take a variety of configurations. Referring to the drawings, Figure 1 shows an embodiment of the invention which employs an endless laminar impressor belt. The apparatus has a conveyer (not shown) for conveying a flat substrate 14 in a horizontal direction. Nip roll 15 is positioned above the surface of the flat substrate, and provids a controlled gap for the coating composition. Nip roll 15 is usually surfaced with a resilient material, such as rubber, and the thickness of the gap for the coating composition is controlled by the pressure of the nip roll against the substrate and the viscosity of the coating composition. Nip roll 15 is cylindrical and rotates in the direction of, and at substantially the same speed as, the movement of the flat substrate 14. Impressor belt 10 is fed between nip roll 15 and flat substrate 14. Idler rollers 13 and 17 feed the impressor belt 10 to nip roll 15 and bias the impressor belt against the nip roll such that it remains in contact with the nip roll. The biasing tension can be maintained with springs or belt tensioners (not shown) on idler rollers 13 or 17.

The gap between nip roll 15 and the surface of the flat substrate 14 will depend upon the speed of the flat substrate, the viscosity of the coating , which is also related to the temperature, and the pressure of the nip roll. Advantageously, the gap ranges from about 0.001 to about 0.08 mm, preferably from about 0.0025 to about 0.025 mm.

Uncured coating composition 23 is applied to the surface of the flat substrate or to the surface of

impressor belt 10 upstream from nip roll 15. The coating is uniformly applied, using a die coater 21 or similar device. The rate of application is controlled to supply adequate coating for a continuous lamination without causing undue build-up at the nip roll.

Downstream from the nip roll 15, the coating is uniformly sandwiched between the surface of the flat substrate and the impressor belt. At this point, the coating is irradiated with a polymerization-initiating radiation. A UV lamp or electron beam radiator 19 is preferably positioned above the moving laminated substrate, and radiation is directed into the coating. The intensity and duration of the radiation are controlled to cure the coating to a solid state, which maintains its surface texture after removal of the impressor belt 10. In the embodiment shown, the radiation device 19 directs radiation through the impressor belt. In such embodiment, the impressor belt is substantially transparent to the radiation. In an alternative embodiment (not shown), the radiation device 19 may be positioned below the flat substrate, with the radiation directed through the flat substrate into the coating. This embodiment may be used when the flat substrate is transparent to the radiation. In yet another embodiment (not shown), radiation devices may be positioned on each side of the flat substrate.

Following radiation curing of the coating, the impressor belt may be removed from the coating. In the embodiment shown in Figure 1, the impressor belt is removed using a stripper roll 16 and a take-up roll 12. The endless impressor belt 10 is then recycled to idler rollers 17 and 13 for reuse. Upon removal of impressor belt 10, the cured coating 24 is firmly adhered to the

flat substrate, and the surface texture of the impressor belt is faithfully transferred to the coating.

In the alternative embodiment shown in Figure 2, the impressor belt 10 is fed from feed roll 26 to idler roller 13. Feed roll 26 contains an adequate length of impressor belt 10 for a production run. Following cure, stripper roll 16 removes impressor belt 10 from the cured coating 24. The removed impressor belt can be stored on a take-up roll (not shown) for reuse or discard.

Yet another embodiment is shown in Figure 3. In this embodiment, impressor belt 10 is left on the cured coating 24 as a masking film. The impressor belt thus protects the coated surface during subsequent handling and transportation of the product, and can be removed by the user at the point of application.

Other embodiments will occur to those skilled in the art. For example, any of the embodiments shown in Figures 1, 2 and 3 can be adapted for simultaneous two-sided coatings. Such two-sided coating can be achieved by placing a laminar impressor apparatus on each side of the moving flat substrate.

The laminar impressor of this invention is well-suited to large-scale automated operations. Conveyer speeds ranging from about 5 ft./min. to about 500 ft./min., preferably from about 15 ft./min. to about 50 ft./min. may be used.

While the invention has been described in connection with certain preferred embodiments, numerous modifications and variations may be made without departing from the spirit and scope of the appended claims.

Claims

1. A laminar impressor for the application of radiation-curable coatings to flat substrates, which comprises:

an impressor belt of non-adhering, flexible film, said belt having a surface texture which is the mirror image of the desired surface texture of the flat substrate being coated;

means for conveying the flat substrate in a linear direction in the plane of its surface being coated;

a rotatable, cylindrical nip roll in closely spaced proximity to the moving surface of the flat substrate, the axis of rotation of the nip roll being substantially parallel to the surface of the flat substrate and substantially perpendicular to the direction of movement of the flat substrate, and the linear speed of the surface of the nip roll being substantially the same as the speed of movement of the flat substrate;

means for feeding the impressor belt between the nip roll and the surface of the flat substrate and biasing the impressor belt against the nip roll, such that it remains in contact with the nip roll and is closely spaced from the surface of the flat substrate; the feeding of said impressor belt being in the direction of and at substantially the same speed as the speed of movement of the flat substrate;

means for applying a controlled amount of a radiation-curable polymeric coating composition to the surface of the flat substrate or the surface of the impressor belt upstream from the nip roll, such that, downstream of the nip roll, the coating composition is sandwiched between the surface of the flat substrate and the impressor belt;

means for directing radiation to the radiation-curable polymeric coating composition downstream from the nip roll, thereby substantially curing the coating composition to a solid state while the impressor belt is still in contact with the coating composition.

2. The laminar impressor of claim 1, wherein the impressor belt is made of a thermoplastic film.

3. The laminar impressor of claim 2, wherein the impressor belt is made of a polyester or polyolefin film.

4. The laminar impressor of claim 1, wherein the impressor belt is substantially transparent to polymerization-initiating radiation.

5. The laminar impressor of claim 4, wherein the impressor belt is substantially transparent to ultraviolet light.

6. The laminar impressor of claim 1, wherein the spacing between the nip roll and the surface of the flat substrate ranges from about 0.0010 to about 0.0800 mm.

7. The laminar impressor of claim 6, wherein the spacing between the nip roll and the surface of the flat substrate ranges from about 0.0025 to about 0.0250 mm.

8. The laminar impressor of claim 1, which further comprises means for removing the impressor belt after curing of the coating, thereby leaving an impression of the surface of the impressor belt on the surface of the radiation-cured coating.

9. The laminar impressor of claim 1, which further comprises a stripper roll, which removes the impressor belt from the cured coating.

10. The laminar impressor of claim 9, wherein the impressor belt is an endless belt which is recycled from the stripper roll to the nip roll.

11. The laminar impressor of claim 9, which further comprises a feed roll for feeding impressor belt to the

and wherein the impressor belt which has been removed from the cured coating is wound onto a take-up roll.

12. The laminar impressor of claim 1 wherein the impressor belt is left on the cured coating as a masking film.

13. A method for applying a radiation-curable coating to a flat substrate using a non-adhering, flexible impressor belt which has a surface texture which is the mirror image of the desired surface texture of the flat substrate, which comprises applying an uncured coating to the flat substrate or to the impressor belt, impressing the impressor belt to the uncured coating to sandwich the coating between the impressor belt and the surface of the flat substrate, irradiating the coating while the impressor belt is still in contact with the coating, and removing the impressor belt.

14. The method of claim 13, wherein the uncured coating is irradiated with a polymerizing amount of radiation through the impressor belt.

15. The method of claim 13, wherein the uncured coating is irradiated with a polymerizing amount of radiation through the flat substrate.

16. The method of claim 13, wherein the radiation is ultraviolet light.

17. The method of claim 13, wherein the radiation is electron beam radiation.

18. The method of claim 13, wherein the thickness of the coating ranges from about 1 m to about 50 m.

19. The method of claim 18, wherein the thickness of the coating ranges from about 4 m to about 12 m.

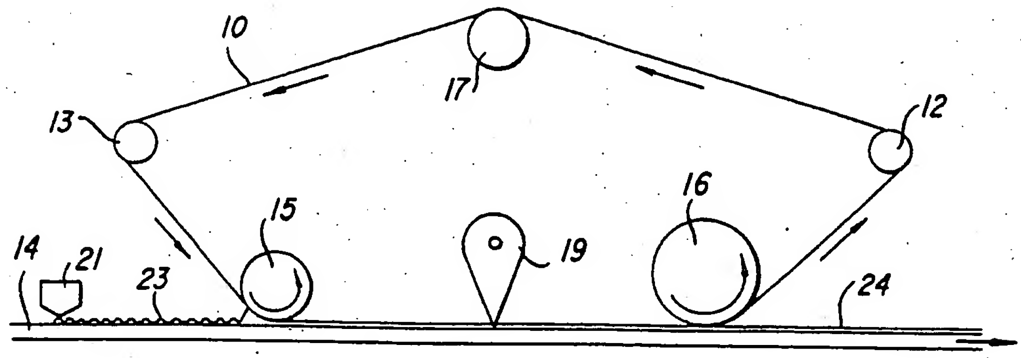

FIG. 1

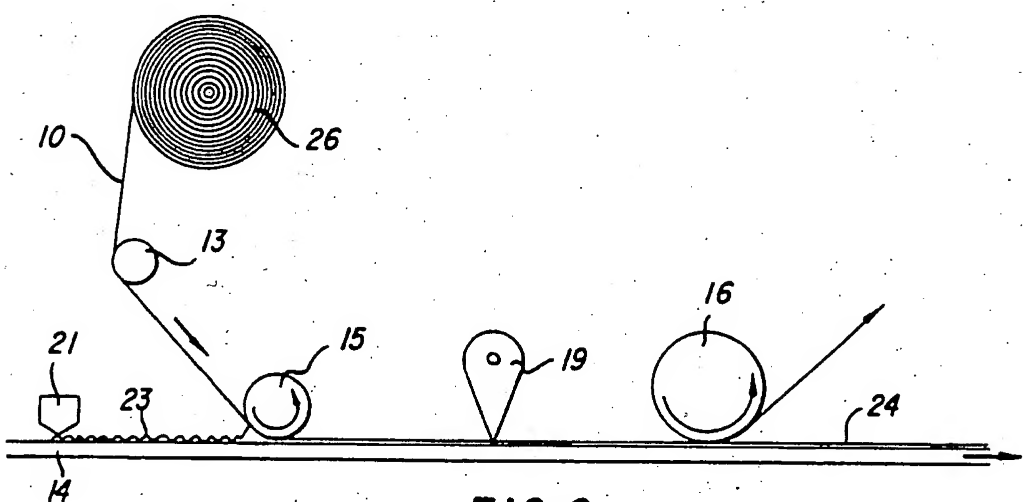

FIG. 2

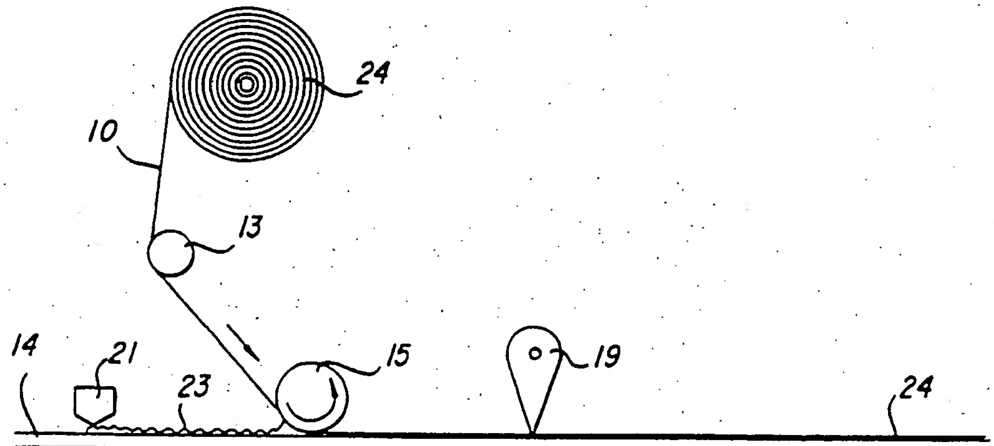

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 89/02541

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: B 05 D 3/12, B 05 D 3/06, B 29 C 43/22, B 05 C 9/12

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	B 05 C, B 29 C

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A, 4810435 (KAMADA et al.) 7 March 1989, see the abstract; figures 1,2; column 2, lines 31-44, 57,59; column 3, lines 3-26; column 4, lines 43-52; column 5, lines 44-59; column 6, lines 18-53; claims 1,3,4	1-19

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* Special categories of cited documents: [10]
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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
20th December 1989	05 FEB 1990
International Searching Authority	**Signature of Authorized Officer**
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. US 8902541

SA 31607

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4810435	07-03-89	JP-A- 62088139	22-04-87

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